



Power & Water – Collision Inevitable?

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Train Wreck?

“Imagine if, in 1905, President Theodore Roosevelt had been able to warn President-to-be Franklin D. Roosevelt about the “dust bowl” disaster of the 1930s...”

“We are... able to predict ... the likelihood of a similar ecological and human crisis over the next 26 years (from) ... population growth, rising electricity demand, and drought. Conventional power plant additions ... threaten to cause massive shortages of water, while forced shutdowns could occur due to lack of water...”

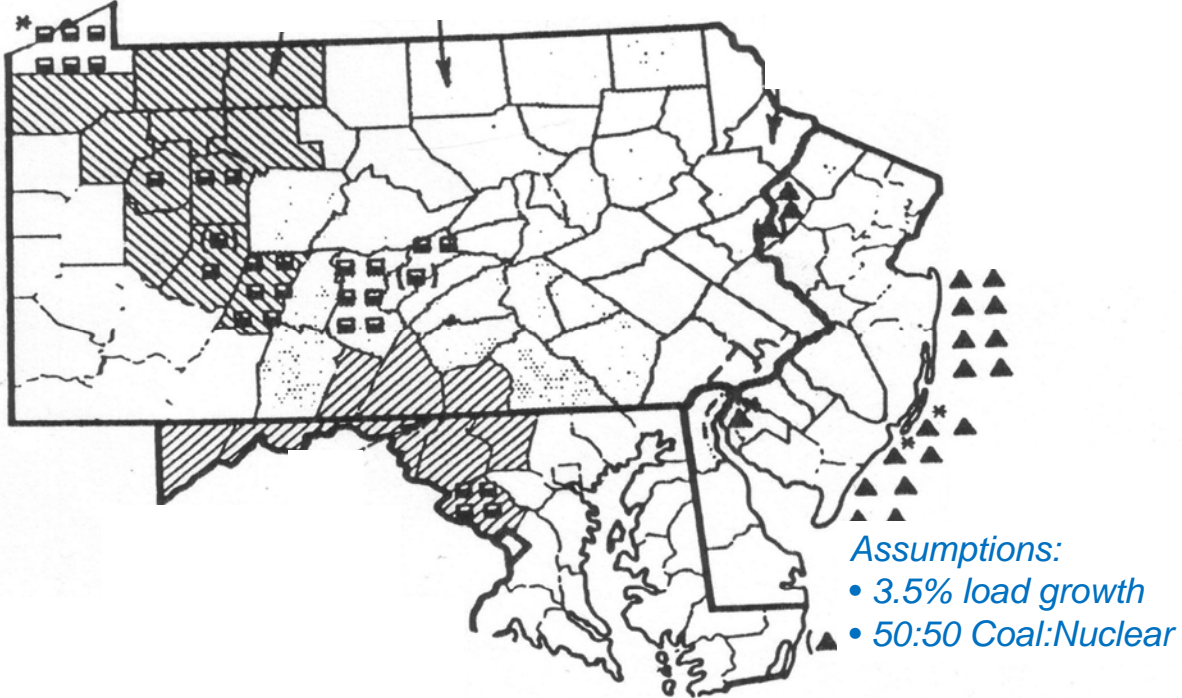
“(T)he President of the United States should immediately issue an executive order to address electricity-water challenges.”



1978 National Coal Utilization Assessment

(Hobbs & Meier, *Water Resources Bulletin*, 1979)

1985-2000 PJM Power Plant Siting Scenario



Yesterday, the crisis loomed:

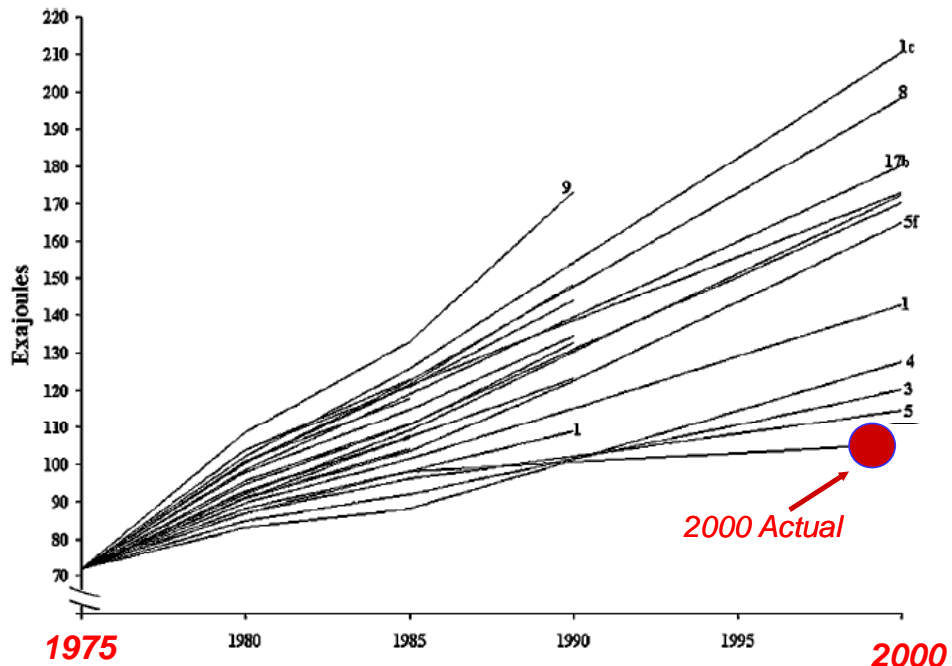


Figure 1 Projections of total U.S. primary energy use from the 1970s. The figure is redrawn from a Department of Energy report (3) and simplified from a summary of dozens of forecasts.

Source: P.P. Craig, A. Gadgil, and J.G. Koomey, "What Can History Teach Us? A Retrospective Examination of Long-Term Energy Forecasts for the United States," *Annual Review of Energy and the Environment*, 27: 83-118

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A Question of Time + Space Scales

- National / long-term vs local / short-term
 - Consumptive use by power plants
 - Technology change
 - National grids / regional water sheds
- Pinch points
 - California Water Board: Once-through cooling rules (~11 GW in California)
 - Groundwater contamination
 - Climate change

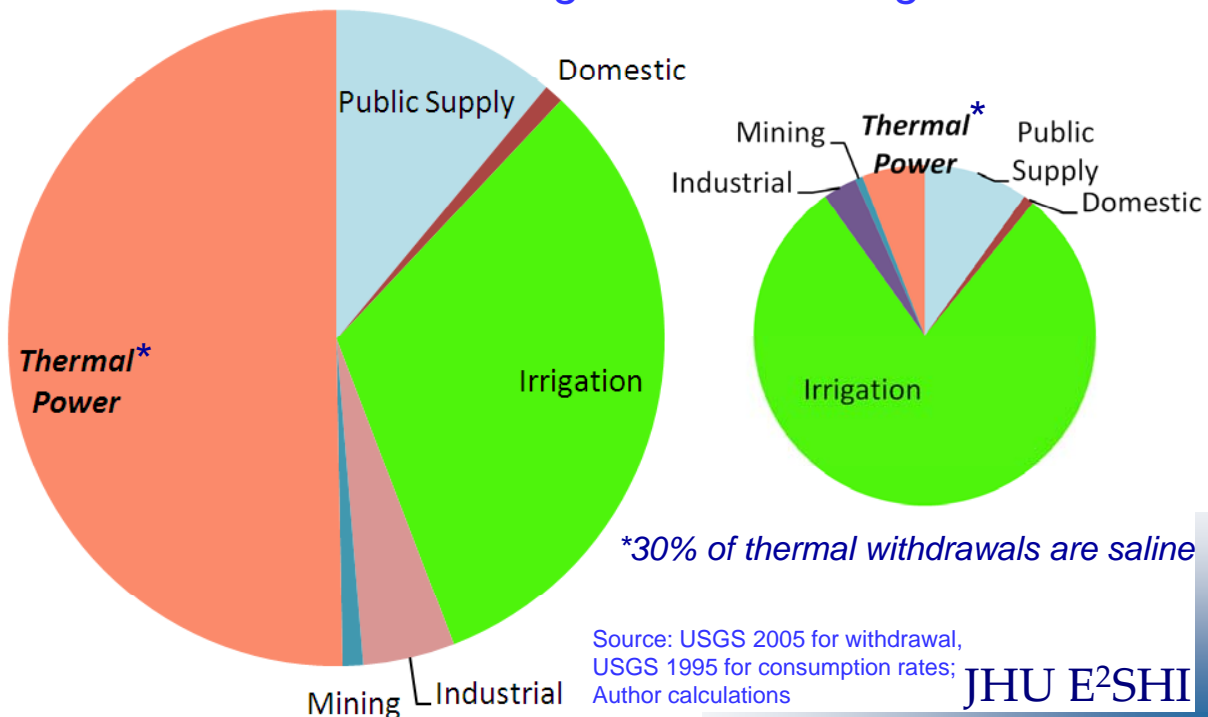
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U.S. Water Use

Withdrawal: ~400 mgd

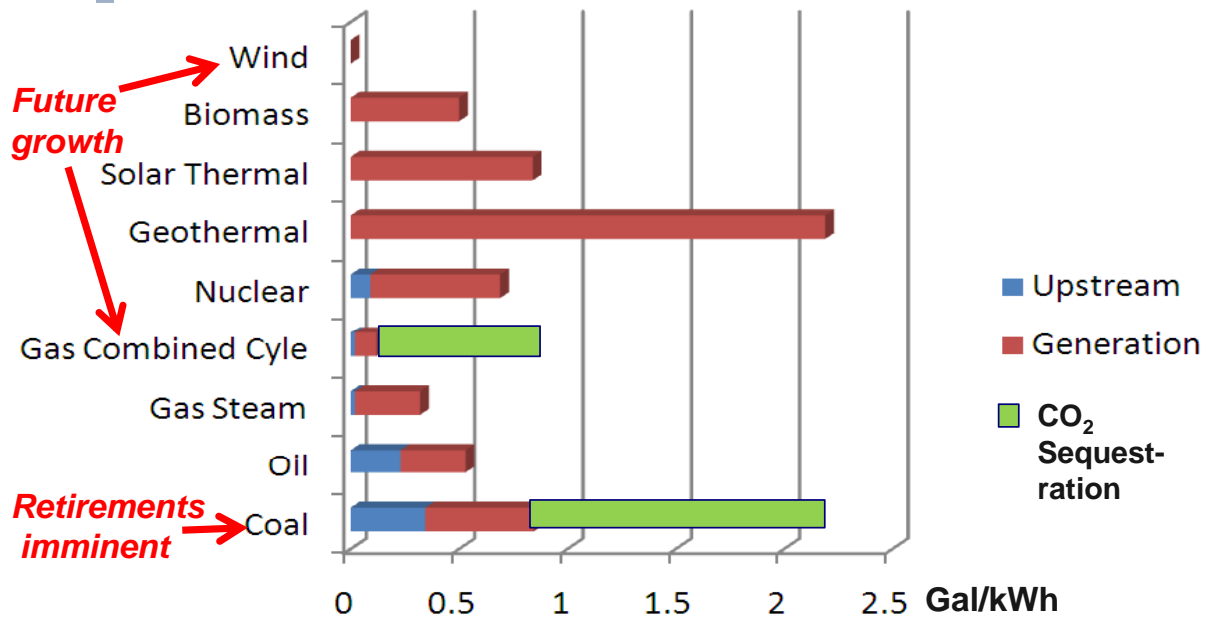
~100 mgd consumed



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Increasing Water Efficiency



Source: --- M. Wu and M.J. Peng, Developing a Tool to Estimate Water Use in Electric Power Generation in the United States, ANL/ESD/11-2, Argonne National Lab, July 2011

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It's About Location and Transportability

- Water: No new large interbasin transfers
- Power:
 - Three Interconnections
 - Seven RTO Markets
 - Grid expansions

Water-Supply Stress from Power Plants

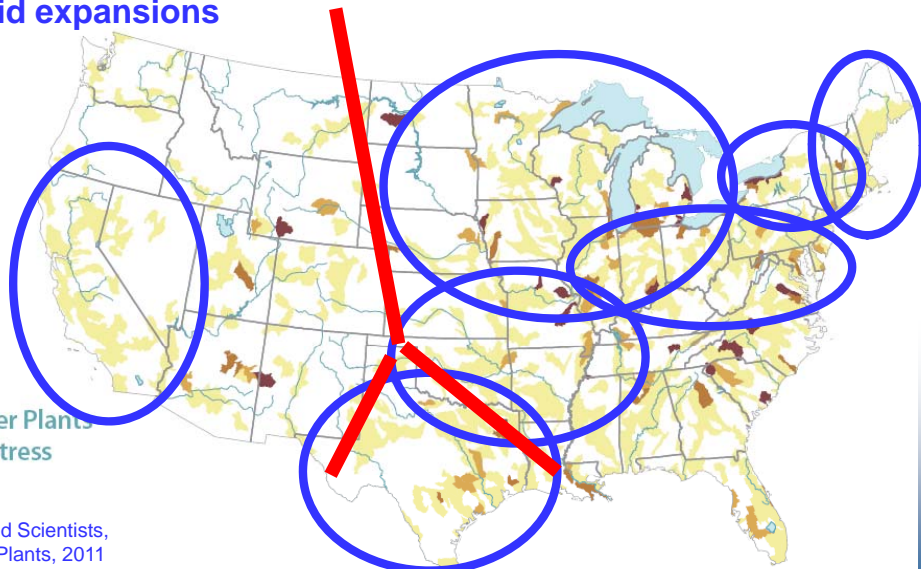
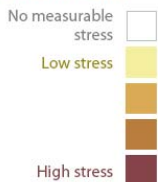


FIGURE 10. Where Power Plants Drive Water-Supply Stress

Source: Union of Concerned Scientists, Freshwater Use by Power Plants, 2011



Pinch Points

- **Water quality**
 - E.g., Fracking & groundwater
- **Once-through cooling retirements**
 - Just when we need flexible capacity!
 - Response: better power market design
- **Climate change**

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Pinch Points, Continued

- **Climate change**
 - Possible loss of hydro and other flexible capacity



Source: *Effects of Climate Change on Energy Production and Use in the U.S.*, US Climate Change Science Program, 2007

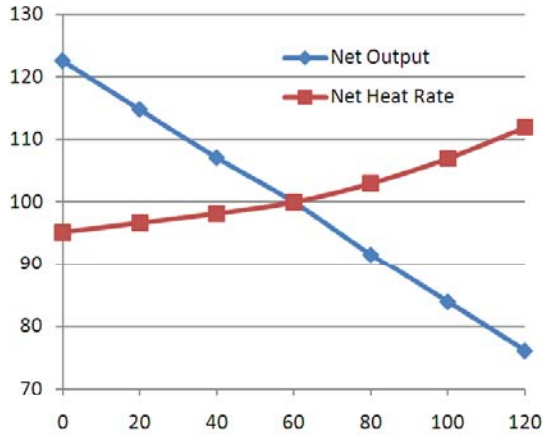
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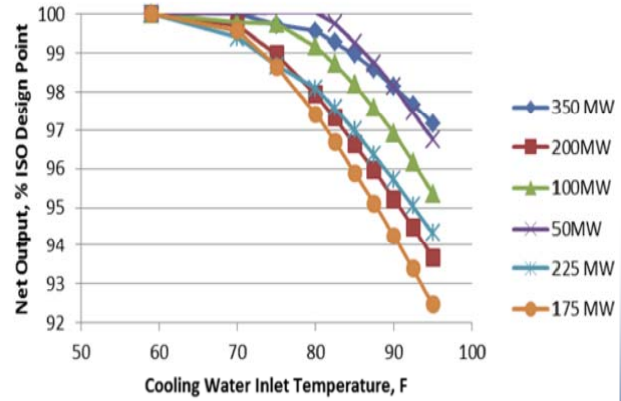
Climate Change, Continued

- Electricity demand increases
- Power plant efficiency decreases

OCCT Output & Efficiency (% of baseline) vs. Air Temperature



Steam Unit Output vs. Cooling Water Temperature



T. Wilbanks, *Vulnerabilities of Energy Infrastructure: Some Analytical Stepping-stones*, ORNL, RIAM Project Meeting, Seattle, WA, 26-27 April 2012

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